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**UTILITY
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(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.

TI-30734

First Named Inventor or Application Identifier

Timothy Schmidl

Title

System And Method Of Communication Using Combined Signal
Parameter Diversity

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APPLICATION ELEMENTS

See MPEP Chapter 600 concerning utility patent application contents

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1. ☒ *Fee Transmittal Form (e.g., PTO/SB/17)
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(preferred arrangement set forth below)
- Descriptive title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R&D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings (if filed)
- Detailed Description
- Claim(s)
- Abstract of the Disclosure
3. ☒ Drawing(s) (35 USC d113) [Total Sheets **6**]
4. Oath or Declaration [Total Pages **1**]
a. ☒ Newly Executed (original or copy)
b. ☐ Copy from a prior application (37 CFR §1.63(d))
(for continuation/divisional with Box 17 completed)
[Note Box 5 below]
i. ☐ **DELETION OF INVENTOR(S)**
Signed statement attached deleting inventor(s)
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see 37 CFR §1.63(d)(2) and 1.33(b)
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The entire disclosure of the prior application, from which a copy of
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being part of the disclosure of the accompanying application and is
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6. ☐ Microfiche Computer Program (Appendix)
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ACCOMPANYING APPLICATION PARTS

8. ☒ Assignment Papers (cover sheet & Documents(s))
9. ☐ 37 CFR §3.73(b) Statement (when there is an assignee) ☒ Power of Attorney
10. ☐ English Translation Document (if applicable)
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SYSTEM AND METHOD OF COMMUNICATION USING COMBINED SIGNAL PARAMETER DIVERSITY

Related Patent Applications

5 This application claims priority under 35 U.S.C. § 119(e)(1) of provisional application serial number 60/146,619, filed 07/30/99, by Timothy M. Schmidl and Anand G. Dabak and further claims priority under 35 U.S.C. §119(e)(1) of provisional application serial number 60/146,477, filed 07/30/99, by Timothy M. Schmidl and Anand G. Dabak.

10 This application is related to U.S. Patent Application entitled *System And Method Of Communication Using Transmit Antenna Diversity Based Upon Uplink Measurements For The TDD Mode Of WCDMA*, docket no. TI-29503, filed on March 10, 2000, by Timothy M. Schmidl and Anand G. Dabak.

Background of the Invention

1. Field of the Invention

15 This invention relates generally to communication systems and more particularly to a diversity system and method of data communication using signal delay diversity combined with communication signal phase and/or amplitude diversity associated with TDMA and CDMA communication signals among others.

2. Description of the Prior Art

25 Delay diversity is a method of transmit antenna diversity in which the same signal is transmitted from multiple antennas, with each antenna having a different time delay. Delay diversity was introduced for TDMA systems such as IS-54 and GSM (global system for mobile communications) by N. Seshadri and J. Winters, *Two Signaling Schemes for Improving the Error Performance of Frequency-Division-Duplex (FDD) Transmission Systems Using Transmitter Diversity*, Vehicular Technology Conference, pp. 508-511 (1993) and A. Wittneben, *A New Bandwidth Efficient Transmit Antenna Modulation Diversity Scheme for Linear Digital Modulation*, International

30

Communications Conference, vol. 3, pp. 1630-1634 (1993), wherein the delays for each antenna are chosen to be a multiple of the symbol interval. Present TDMA systems are characterized by transmission of different data signals over a common channel by assigning each signal a unique time period. These data signals are typically transmitted as binary phase shift keyed (BPSK), Gaussian minimum shift keyed (GMSK), or quadrature phase shift keyed (QPSK) data symbols during such unique time periods. These unique periods are allocated to a selected receiver to determine the proper recipient of a data signal. Allocation of such unique periods establishes a communication channel between a transmitter and selected remote receivers for narrow band transmission. This communication channel may be utilized for cable networks, modem transmission via phone lines or for wireless applications.

A selected TDMA receiver must determine both carrier phase and symbol timing of its unique period from the received signal for data recovery. The carrier phase is necessary for generating a reference carrier with the same phase as the received signal. This reference carrier is used to coherently demodulate the received signal, thereby creating a baseband signal. Symbol timing synchronization of the receiver with the transmitter is necessary for the receiver to extract correct data symbols from the baseband signal.

Delay diversity for a synchronous CDMA system (IS-95) was disclosed in U.S. Patent No. 5,781,541, entitled *CDMA System Having Time-Distributed Transmission Paths for Multipath Reception*, by A. Schneider, issued July 14, 1998 wherein the delays for each antenna are greater than a chip interval and less than the base station sequence offset between base stations. The Seshadri et al., Wittneben and Schneider references are incorporated by reference herein. Delay diversity for another CDMA communication system and using a distributed antenna system to provide multipath signals in order to facilitate signal diversity for enhanced system performance was disclosed by Gilhousen, et al. in U.S. Patent No. 5,280,472, entitled *CDMA Microcellular Telephone System and Distributed Antenna System Therefor*, issued January 18, 1994. A communication system having the advantages of delay diversity in combination with phase and/or amplitude diversity is however, presently unknown. In view of the above, a wireless communication system having selectively variable transmit antenna delays or signal

Summary of the Invention

The present invention is directed to a system and method of communication using selectively variable transmit antenna delays or signal delays combined with selectively adjustable signal phase and/or or amplitude characteristics, associated with multiple antennas to accommodate different communication modes such as TDMA and CDMA, among others. The signals for each channel are delayed and otherwise adjusted at baseband, so different delays and signal characteristics can be used for each channel. The delay between the antennas can be chosen so that the strongest paths do not overlap such that full diversity can be achieved. For broadcast channels transmitted to all mobile terminals, there is less flexibility in choosing the delays between antennas since the same delay is used for all users. In this case, the antenna delays can be chosen so as to benefit the maximum number of users or the users at the edge of the cell. Where full diversity cannot be achieved due to overlapping signal paths, the respective signal amplitude and phase characteristics can further be adjusted at the base station such that any overlapping signals are constructively combined to produce enhanced and more reliable signal reception at a mobile terminal.

Thus, a method of communicating data between a transmitter having a plurality of antennas and at least one remote receiver according to one embodiment of the present invention comprises the steps of:

selectively shifting the phase and/or amplitude of a data signal produced at a transmitter, to generate derived versions of the data signal;

transmitting from the transmitter, the derived versions of the data signal to each antenna within the plurality of antennas; and

providing a distinct delay associated with each derived version of the data signal and its respective antenna.

A communication system according to one embodiment of the present invention comprises:

a transmitter having a plurality of spaced apart antennas;

signal shifting means for selectively shifting the phase and/or amplitude of a communication signal produced at the transmitter to generate derived versions of the communication signal;

signal distribution means for coupling communication signals between the transmitter and the plurality of spaced apart antennas; and

delay means operatively coupled to the antennas and the signal distribution means for providing a distinct delay in each of the derived communication signals coupled between the transmitter and the plurality of spaced apart antennas.

A data communication system according to another embodiment of the present invention comprises:

a transmitter having a plurality of spaced apart antennas;

at least one remote receiver in communication with the transmitter;

means for selectively shifting the phase and/or amplitude of a communication signal produced at the transmitter to generate derived versions of the communication signal; and

means for providing a distinct delay associated with each antenna such that derived versions of the communication signals coupled between the transmitter and the plurality of spaced apart antennas can be demodulated within the at least one remote receiver.

A data communication system according to yet another embodiment of the present invention comprises:

a transmitter having a plurality of spaced apart antennas;

means for selectively shifting the phase and/or amplitude of a communication signal produced at the transmitter to generate derived versions of the communication signal;

means for transmitting from the transmitter, derived versions of a communication signal to each antenna within the plurality of spaced apart antennas; and

means for providing a distinct delay associated with each derived version of the communication signal and its respective antenna within the plurality of spaced apart antennas.

A data communication system according to still another embodiment of the present invention comprises:

a transmitter configured to communicate with at least one remote receiver, the transmitter having a plurality of spaced apart antennas and further having:

- 5 a data processor;
- a data input device in communication with the data processor;
- an algorithmic software directing the data processor; and
- a data storage unit, wherein discrete signal data is stored and supplied to the data processor such that the data processor, directed by the algorithmic software, can
- 10 automatically derive communication signal phase parameters and/or communication signal amplitude parameters and communication signal delay parameters using algorithmically defined relationships associated with the discrete signal data such that derived signals communicated between the transmitter and each respective antenna will be characterized by distinct communication signal phase parameters and/or distinct
- 15 communication signal amplitude parameters and distinct communication signal delay parameters.

A data communication system according to yet another embodiment of the present invention in which system users communicate information signals through a transmitter using TDMA or CDMA communication signals, comprises a transmitter

20 having an antenna system comprising:

- a plurality of spaced apart antennas;
- means for distributing communication signals between a transmitter and the plurality of spaced apart antennas;
- means for selectively phase shifting and/or amplitude scaling communication
- 25 signals to generate derived communication signals at a transmitter; and
- variable delay means operatively coupled to the plurality of spaced apart antennas and the signal distribution means for providing selectively adjustable delays associated with the derived communication signals and the plurality of spaced apart antennas.

As used herein, the following words have the following meanings. The words

30 “algorithmic software” means an algorithmic program used to direct the processing of data by a computer or data processing device. The words “data processing device” as

used herein refer to a CPU, DSP, microprocessor, micro-controller, or other like device and an interface system. The interface system provides access to the data processing device such that data could be entered and processed by the data processing device. The words “discrete data” as used herein are interchangeable with “digitized data” and

5 “digitized data” as used herein means data which are stored in the form of singularly isolated, discontinuous data or digits.

In one aspect of the invention, a multiple transmit antenna transmitter utilizes delay diversity in combination with phase diversity and/or amplitude diversity to deliver either TDMA or CDMA signals, among others, to a remote receiver.

10 In another aspect of the invention, a multiple transmit antenna transmitter utilizes adaptive variable delay diversity in combination with either phase diversity or amplitude diversity or both to deliver either TDMA or CDMA mode signals, among others, to a remote receiver.

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Brief Description of the Drawings

Other aspects and features of the present invention and many of the attendant
5 advantages of the present invention will be readily appreciated as the same become better
understood by reference to the following detailed description when considered in
connection with the accompanying drawings in which like reference numerals designate
like parts throughout the figures thereof and wherein:

Figure 1 is a block diagram of a typical cell showing a single base station in
10 communication with a plurality of mobile terminals;

Figure 2 is a block diagram illustrating one system and method of implementing
delay diversity at the base station shown in Figure 1 and having K channels and N
antennas suitable for accommodating TDMA or CDMA mode data/voice communication,
among others, according to one embodiment of the present invention;

15 Figure 3 is a block diagram illustrating a method of choosing channel delays
associated with multiple antennas according to one embodiment of the present invention;

Figure 4 is a diagram of a delay profile at a mobile terminal with a delay of 2
chips between two transmit antennas at the base station shown in Figure 1 according to
one embodiment of the present invention;

20 Figure 5 is a diagram of a delay profile at a mobile terminal with a delay of 1 chip
between two transmit antennas at the base station shown in Figure 1 according to one
embodiment of the present invention;

Figure 6 is a simplified block diagram illustrating a base station configured to
implement combined signal parameter diversity according to one embodiment of the
25 present invention; and

Figure 7 is a simplified block diagram illustrating application of the present
method to a well known TDMA communication system according to one embodiment of
the present invention wherein transmission of different derived data signals is
accommodated over a common channel by assigning each derived signal a unique time
30 period.

While the above-identified drawing figures set forth alternative embodiments, other embodiments of the present invention are also contemplated, as noted in the discussion. In all cases, this disclosure presents illustrated embodiments of the present
5 invention by way of representation and not limitation. Numerous other modifications and embodiments can be devised by those skilled in the art which fall within the scope and spirit of the principles of this invention.

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Detailed Description of the Preferred Embodiments

Figure 1 is a block diagram of a typical cell 100 showing a single base station 102 in communication with a plurality of mobile terminals 104, 106, 108. These devices
 5 communicate within the cell 100 using a predetermined mode of data communication such as, for example, time division multiple access (TDMA) or code division multiple access (CDMA). Delay diversity within the cell 100 is accomplished by transmitting derived versions of the same signal from different antennas with at least one distinct delay between any two antennas. The derived versions of the signal are obtained by
 10 scaling the amplitude and/or phase shifting the communication signal to be transmitted. This amplitude scaling is most preferably implemented at the base station 102, whereas the communication signal phase shifting can be optionally implemented at either the base station 102 or at the transmit antennas associated with the base station 102. The simplest form of delay diversity would involve simply transmitting the same signal from different
 15 antennas with at least one distinct delay between any two antennas. The desired delay is most preferably implemented at the base station, but can be implemented at the antenna system associated with the base station 102 as well.

Figure 2 is a block diagram 200 illustrating one implementation of combined signal parameter diversity at the base station 102 shown in Figure 1 and having K
 20 channels 202-206 and N antennas 208-212 suitable for accommodating the desired mode of data communication according to one embodiment of the present invention. Transmit antenna delay diversity is generally implemented with fixed delays for each antenna 208-212 (usually a 1-chip delay per antenna for CDMA systems and a 1-symbol delay per antenna for TDMA systems). Delay diversity, as stated above, is a method of transmit
 25 antenna diversity in which the same signal is transmitted from multiple antennas, with each antenna having a different time delay for the same signal. With continued reference to Figure 2, the signals associated with each channel 202-206 may be delayed at baseband, so different delays 214-230 can be used for each channel 202-204.

As stated above, delay diversity within the cell 100 is accomplished by
 30 transmitting different derived versions of the same signal from different antennas 208-212 with at least one distinct delay 214-230 between any two antennas. The derived

versions of the signal are obtained by scaling the amplitude and/or phase shifting via multiplier/phase shifting elements 232-248 in a manner familiar to those skilled in the art of signal processing. The present inventors realized that simply using variable delay parameters alone to accomplish transmit diversity may not be enough to accommodate reliable signal reception at a mobile terminal under certain unique situations such as discussed in further detail herein below. When these unique situations occur, it is also advantageous to either phase shift the signals to be transmitted and/or scale the signal amplitude of the signals to be transmitted. These unique situations can be determined by taking channel measurements 256 for the different signal paths 252-254 associated with the multiple antennas 208-212. These channel measurements 256 will provide an indication of the signal phase and signal amplitude associated with a particular signal to be transmitted over each signal path 252-254. Thus, by feeding back the requisite channel measurement data, e.g. chip delay, the derived versions of the communication signals can be phase shifted and/or amplitude scaled to further optimize the reliability of the signal transmitted from the base station 102 via the multiple antennas 208-212. As also stated above, the simplest form of delay diversity would involve simply transmitting the same signal from different antennas with at least one distinct delay between any two antennas such as depicted in Figure 2.

Application of the present technique to a well known TDMA communication system is similarly shown in Figure 7, wherein transmission of different derived data signals is accommodated over a common channel 702 by assigning each derived signal a unique time period (delay) 704, 706, 708. The same TDMA system signal is transmitted from multiple antennas 710, 712 714, with each antenna having a different time delay 704-708 for the same signal. Since the signals associated with the common channel 702 may be delayed at baseband, different delays 704-708 can be easily used for each TDMA system channel (e.g. channel 702).

Delay diversity within the TDMA system shown in Figure 7 is similarly achieved in accordance with the present method by transmitting different derived versions of the same TDMA system signal from different antennas 710-714 with at least one distinct delay 704-708 between any two antennas. The derived versions of the signal are obtained by scaling the amplitude and/or phase shifting via multiplier/phase shifting

elements 716–720 in a manner familiar to those skilled in the art of signal processing. Since use of delay parameters alone to accomplish transmit diversity may not be enough to accommodate reliable signal reception at a mobile terminal under certain unique situations, it is also advantageous to either phase shift the signals to be transmitted and/or scale the signal amplitude of the signals to be transmitted. These unique situations can be determined by taking channel measurements 730 for the different signal paths 722-728 associated with the multiple antennas 710-714. These channel measurements 730 will provide an indication of the signal phase and signal amplitude to be associated with a particular signal to be transmitted over each signal path 732-736. Thus, by feeding back the requisite TDMA system channel measurement data, e.g. symbol delay, the derived versions of the TDMA communication system signals can be phase shifted and/or amplitude scaled to further optimize the reliability of the signal transmitted from the base station 102 via the multiple antennas 710-714.

As seen in Figure 3, the base station 102 can measure the delay profile 302, 304, 306 in the uplink transmission from a mobile terminal 104, 106, 108 to implement one method of choosing channel delays 214-230 associated with multiple antennas 208-212 according to one embodiment of the present invention. The delay 214-230 between the antennas 208-212 can be chosen so that the strongest signal paths between the base station 102 and the mobile terminals 104, 106, 108 do not overlap, thereby achieving full diversity. Thus, the present method is distinct from those presently known communication methods since it is adaptive in that the delay 214-230 is variable. The present method is also distinct from those presently known communication methods since it further strengthens the foregoing delay diversity by also implementing signal phase shifting and/or amplitude adjustment techniques to further optimize reception capabilities at the mobile terminals 104, 106, 108. The variable delay 214-230 need not remain fixed for a particular channel 202, 204, 206, but can be altered accordingly as necessary in order to meet the needs of a changing path profile between the base station 102 and one or more mobile terminals 104, 106, 108. There is of course, less flexibility in choosing the delays between antennas for broadcast channels transmitted to all mobile terminals since the same delay is used for all users. In this case, as stated herein before, the

antenna delays 214-230 can be chosen so as to benefit the maximum number of users or the users at the edge of the cell.

Figure 4 is a diagram of a signal delay profile 400 at a mobile terminal 104, 106, 108 with a delay of 2 chips between two transmit antennas at the base station 102 shown in Figure 1 according to one embodiment of the present invention. When the channel impulse response, for example, has two paths separated by 1-chip and having relative powers of 0dB and -10dB respectively, the foregoing 2-chip delay will provide the signal delay profile depicted in Figure 4 at the mobile terminal. Since the paths from the two antennas do not overlap, there is a full 4-path diversity.

Figure 5 is a diagram of a delay profile 500 at a mobile terminal with a delay of only 1-chip between two transmit antennas at the base station shown in Figure 1 according to one embodiment of the present invention. When the above channel impulse response having two paths separated by 1-chip and further having relative powers of 0dB and -10dB respectively is transmitted with only a 1-chip delay, the signal delay profile 500 is seen by the mobile terminal. In this instance, the second path from antenna 1 overlaps with the first path from antenna 2, thereby resulting in less desirable 3-path diversity. The channel measurements 256 associated with signal delay, signal amplitude and signal phase parameters along signal paths 250-254 shown in Figure 2 then are indicative of the instant conditions.

As shown in Figure 6, discrete data associated with these channel measurements 256 is stored in a data storage unit 602 within the base station 102 so that it can be supplied to a data processor 604 such as a digital signal processor (DSP). The data processor (DSP) 604 is directed by an algorithmic software 606, also stored within the base station 102, such that it can automatically derive signal parameters using algorithmically defined relationships associated with discrete channel measurement data. These derived signal parameters are then used to characterize each derived signal communicated between the base station 102 and each respective antenna 208-212. With continued reference to Figure 5, the present technique will then ensure the overlapping signal paths will inherit constructive rather than destructive signal transmission characteristics. The overlapping signals from Antenna 1 and Antenna 2, for example, will be synchronized such that their respective phase relationships will operate

constructively to enhance the signal amplitude along the overlapping signal path. The mobile terminal 104-108 will see a stronger and more reliable signal using the present technique as contrasted with a weaker and marginally acceptable signal when simply using delay diversity alone to distinguish overlapping communication signals. As

5 described in U.S. Patent Application entitled *System And Method Of Communication Using Transmit Antenna Diversity Based Upon Uplink Measurements For The TDD Mode Of WCDMA*, docket no. TI-29503, filed on March 10, 2000, by Timothy M. Schmidl and Anand G. Dabak, the total impulse response of each channel 202-206, including the delay spread of the transmit antennas 208-212, must be kept less than the

10 length of the channel estimation window associated with the base station 102 such that signals received by a mobile terminal 104-108 via one antenna will not overlap signals received by a mobile terminal via a different antenna. The foregoing delay spread is most preferably limited to $M=16$ chips or less as shown by equation (1) below.

$$15 \quad |Delay_{k,i} - Delay_{k,j}| \leq M \text{ chips}; i \in [1,2,\dots,N]; j \in [1,2,\dots,N] \quad (1)$$

This invention has been described in considerable detail in order to provide those skilled in the wireless communication art with the information need to apply the novel principles and to construct and use such specialized components as are required. In view

20 of the foregoing descriptions, it should be apparent that the present invention represents a significant departure from the prior art in construction and operation. However, while particular embodiments of the present invention have been described herein in detail, it is to be understood that various alterations, modifications and substitutions can be made therein without departing in any way from the spirit and scope of the present invention, as

25 defined in the claims which follow. For example, the present combined parameter diversity technique is useful in providing enhanced communication for any number of communication modes and is not limited in application to either TDMA or CDMA communication modes. Further, the exemplary combined signal parameter diversity of the present invention can be implemented in hardware or software, or a combination of

30 both. In a preferred embodiment, the functions of a data communication system designed

in conformance with the principals set forth herein are implemented as one or more integrated circuits using a suitable processing technology, e.g., CMOS, HBT.

As another example, at least portions of the present invention may be implemented in computer programs, i.e. algorithms, executing on programmable
5 computers each comprising a data processor, a data storage system, including both volatile and non-volatile memory and/or data storage devices, at least one input device, and at least one output device. Program code is applied to input data to perform the functions described herein and generate output information. The output information is applied to one or more output devices, in known fashion. Each such program may be
10 implemented in a high level procedural or object oriented programming language to communicate with a computer system. However, the programs can be implemented in assembly or machine language, if desired. In any case, the language may be a compiled or interpreted language. Portions of the inventive structure and method may also be considered to be implemented as a computer-readable storage medium, configured with a
15 computer program, where the storage medium so configured causes a data processor to operate in a specific and predefined manner to perform the functions described herein. An example of one such type of data processor is a digital signal processor (DSP).

WHAT IS CLAIMED IS:

1. A method of communicating data between a transmitter having a plurality of antennas and at least one remote receiver, the method comprising the steps of:
 - selectively phase shifting data communication signals produced at the transmitter to generate derived versions of channel communication signals, each derived version of the channel communication signals having its desired data communication signal phase shift;
 - transmitting from the transmitter, derived versions of the channel communication signal to each antenna within the plurality of antennas; and
 - providing a distinct delay associated with each derived version of the channel communication signal and its respective antenna.
2. The method according to claim 1 further comprising the step of receiving at the transmitter, data communication uplink signals from each remote receiver in communication with the transmitter and estimating a path profile associated with each received uplink signal.
3. The method according to claim 2 further comprising the step of determining a distinct communication signal delay associated with each communication channel with a plurality of communication channels, wherein each communication channel signal delay is derived from data associated with the respective uplink signal.
4. The method according to claim 1 further comprising the step of selectively amplitude scaling data communication signals produced at the transmitter such that each derived version of the channel communication signals will further have a desired channel communication signal amplitude.

5. The method according to claim 1 further comprising the step of altering the distinct delay associated with a derived version of the channel communication signal and its respective antenna if and when an estimated path profile associated with the specific channel communication signal changes from a prior estimated path profile.
6. The method according to claim 1 wherein the derived versions of a channel communication signal transmitted to each antenna are associated with a code division multiple access (CDMA) data signal.
7. The method according to claim 1 wherein the derived versions of a channel communication signal transmitted to each antenna are associated with a time division multiple access (TDMA) data signal.
8. A method for communicating data between a transmitter having a plurality of antennas and at least one remote receiver, the method comprising the steps of:
- receiving at the transmitter, data communication uplink signals from each remote receiver in communication with the transmitter and estimating a path profile associated with each received uplink signal;
 - determining a distinct communication signal delay associated with each communication channel within a plurality of communication channels, wherein each communication channel signal delay is derived from data associated with the respective uplink signal;
 - transmitting from the transmitter, a communication signal via each communication channel to each antenna within the plurality of antennas;
 - providing a distinct delay associated with each communication channel and its respective antenna;
 - measuring channel information between the transmitter and the plurality of antennas, the channel information selected from the group consisting of signal amplitude, signal phase and signal delay;

determining a desired communication signal phase shift associated with each communication channel from the measured channel information; and selectively phase shifting communication signals produced at the transmitter to generate derived versions of channel communication signals, each derived version of the channel communication signals having its desired communication signal phase shift.

9. The method according to claim 8 further comprising the step of altering the distinct delay associated with a channel communication signal and its respective antenna if and when the estimated path profile associated with the specific channel communication signal changes from its prior estimated path profile.

10. The method according to claim 8 wherein the step of receiving at the transmitter, a communication uplink signal from each remote receiver in communication with the transmitter and estimating a path profile associated with each received uplink signal comprises the step of receiving a time division multiple access (TDMA) data signal.

11. The method according to claim 8 wherein the step of receiving at the transmitter, a communication uplink signal from each remote receiver in communication with the transmitter and estimating a path profile associated with each received uplink signal comprises the step of receiving a code division multiple access (CDMA) data signal.

12. A communication system comprising:
a transmitter having a plurality of spaced apart antennas;
signal distributing means for coupling communication signals between the transmitter and the plurality of spaced apart antennas;
delaying means operatively coupled to the antennas and the signal distributing means for providing a distinct delay in each of the communication

signals coupled between the transmitter and the plurality of spaced apart antennas;
and

channel measuring means operatively coupled to the signal distributing means for providing a derived version of each communication signal transmitted from a transmitter channel to the plurality of spaced apart antennas.

13. The communication system according to claim 12 wherein each communication signal is associated with a code division multiple access (CDMA) data signal.

14. The communication system according to claim 12 wherein each communication signal is associated with a time division multiple access (TDMA) data signal.

15. The communication system according to claim 12 wherein the channel measuring means for providing a derived version of each communication signal is configured to phase shift a communication signal transmitted from a transmitter channel to the plurality of spaced apart antennas.

16. The communication system according to claim 15 wherein the channel measuring means for providing a derived version of each communication signal is further configured to amplitude scale a communication signal transmitted from a transmitter channel to the plurality of spaced apart antennas.

17. The communication system according to claim 12 wherein the channel measuring means for providing a derived version of each communication signal is configured to amplitude scale a communication signal transmitted from a transmitter channel to the plurality of space apart antennas.

18. A data communication system comprising:
a transmitter having a plurality of spaced apart antennas;
at least one remote receiver in communication with the transmitter;
means for providing a derived version of each communication signal transmitted from a transmitter channel to the plurality of spaced apart antennas;
and
means for providing a distinct delay associated with each antenna such that a derived version of a communication signal coupled between the transmitter and the plurality of spaced apart antennas can be demodulated within the at least one remote receiver.
19. The data communication system according to claim 18 wherein the means for providing a distinct delay is capable of providing a distinct delay associated with each antenna such that a code division multiple access (CDMA) communication signal coupled between the transmitter and the plurality of spaced apart antennas can be demodulated within the at least one remote receiver.
20. The data communication system according to claim 18 wherein the means for providing a distinct delay is capable of providing a distinct delay associated with each antenna such that a time division multiple access (TDMA) communication signal coupled between the transmitter and the plurality of spaced apart antennas can be demodulated within the at least one remote receiver.
21. The data communication system according to claim 18 wherein the means for providing a derived version of each communication signal is configured to phase shift a communication signal transmitted from a transmitter channel to the plurality of spaced apart antennas.

22. The data communication system according to claim 18 wherein the means for providing a derived version of each communication signal is further configured to amplitude scale a communication signal transmitted from a transmitter channel to the plurality of spaced apart antennas.

23. The data communication system according to claim 18 wherein the means for providing a distinct delay associated with each antenna is configured to alter a distinct delay associated with a channel communication signal and its respective antenna if and when a path profile associated with the specific channel communication signal changes from a prior path profile.

24. A data communication system comprising:
a transmitter having a plurality of spaced apart antennas;
means for transmitting from the transmitter, derived versions of a communication signal to each antenna within the plurality of spaced apart antennas; and
means for providing a distinct delay associated with each derived version of the communication signal and its respective antenna within the plurality of spaced apart antennas.

25. The data communication system according to claim 24 further comprising means for amplitude scaling a communication signal to generate a derived version of the communication signal.

26. The data communication system according to claim 24 further comprising means for phase shifting a communication signal to generate a derived version of the communication signal.

27. The data communication system according to claim 24 further comprising means for scaling and phase shifting a communication signal to generate a derived version of the communication signal.

28. A data communication system comprising:
- a transmitter configured to communicate with at least one remote receiver, the transmitter having a plurality of spaced apart antennas and further having:
 - a data processor;
 - a data input device in communication with the data processor;
 - an algorithmic software directing the data processor; and
 - a data storage unit, wherein discrete channel measurement data and discrete communication signal uplink data associated with at least one remote receiver in communication with the transmitter is stored and supplied to the data processor such that the data processor, directed by the algorithmic software, can automatically derive communication signal parameters using algorithmically defined relationships associated with the discrete channel measurement data such that derived communication signals communicated between the transmitter and each respective antenna will be characterized by at least one distinct signal parameter selected from the group consisting of signal phase and signal amplitude; and further wherein the data processor is further directed by the algorithmic software such that it can automatically determine signal path profile parameters using algorithmically defined relationships associated with discrete communication signal uplink data such that a signal communicated between the transmitter and each antenna will be characterized by a distinct signal delay.
29. The data communication system according to claim 28 further comprising at least one remote receiver.
30. The data communication system according to claim 29 wherein the at least one remote receiver is configured to demodulate a time division multiple access (TDMA) signal generated by the transmitter.

31. The data communication system according to claim 29 wherein the at least one remote receiver is configured to demodulate a code division multiple access (CDMA) signal generated by the transmitter.

32. A communication system in which system users communicate information signals through a transmitter, the transmitter having an antenna system comprising:

- a plurality of spaced apart antennas;

- signal distributing means for coupling communication signals between a transmitter and the plurality of spaced apart antennas;

- signal deriving means operatively coupled to the signal distributing means for providing communication signal phase parameters associated with communication signals, wherein the phase parameters are determined from channel measurement information associated with the signal distributing means; and

- variable delaying means operatively coupled to the plurality of spaced apart antennas and the signal distribution means for providing discrete delays associated with the communication signals and the plurality of spaced apart antennas.

33. The communication system according to claim 32 wherein the variable delaying means comprises:

- a data processor;

- an algorithmic software directing the data processor; and

- a data storage unit, wherein discrete signal uplink data associated

with at least one mobile terminal in communication with the transmitter is stored and supplied to the data processor such that the data processor, directed by the algorithmic software, can automatically determine signal path profile parameters using algorithmically defined relationships associated with the discrete signal uplink data such that a signal communicated between the transmitter and each antenna will be characterized by a signal delay distinct to each antenna.

34. The communication system according to claim 33 wherein the algorithmic software is configured to further direct the data processor such that the data processor can determine new signal path profile parameters to re-characterize the signal delay distinct to each antenna when the discrete signal uplink data received by the transmitter are sufficiently changed to require that a distinct signal delay change by at least one chip from an existing distinct signal delay.

35. The communication system according to claim 32 wherein the communication signals are associated with code division multiple access (CDMA) data.

36. The communication system according to claim 32 wherein the communication signals are associated with time division multiple access (TDMA) data.

37. A method of communicating data between a transmitter having a plurality of antennas and at least one remote receiver, the method comprising the steps of:

selectively amplitude scaling data communication signals produced at the transmitter to generate derived versions of channel communication signals, each derived version of the channel communication signals having its desired data communication signal amplitude;

transmitting from the transmitter, derived versions of the channel communication signal to each antenna within the plurality of antennas; and

providing a distinct delay associated with each derived version of the channel communication signal and its respective antenna.

38. The method according to claim 37 further comprising the step of selectively phase shifting data communication signals produced at the transmitter such that each derived version of the channel communication signals will further have a desired channel communication signal phase shift.

39. The method according to claim 37 further comprising the step of altering the distinct delay associated with a derived version of the channel communication signal and its respective antenna if and when an estimated path profile associated with the specific channel communication signal changes from a prior estimated path profile.

40. The method according to claim 37 wherein the derived versions of a channel communication signal transmitted to each antenna are associated with a code division multiple access (CDMA) data signal.

41. The method according to claim 37 wherein the derived versions of a channel communication signal transmitted to each antenna are associated with a time division multiple access (TDMA) data signal.

42. A data communication system comprising:
a transmitter having a plurality of spaced apart antennas;
at least one remote receiver in communication with the transmitter;
means for providing a derived version of each communication signal transmitted from a transmitter channel to the plurality of spaced apart antennas, wherein the means for providing a derived version of each communication signal is configured to phase shift a communication signal transmitted from the transmitter to the plurality of spaced apart antennas; and
means for providing a distinct delay associated with each antenna such that a derived version of a communication signal coupled between the transmitter and the plurality of spaced apart antennas can be demodulated within the at least one remote receiver.

43. The data communication system according to claim 42 wherein the means for providing a distinct delay is capable of providing a distinct delay associated with each antenna such that a code division multiple access (CDMA) communication signal coupled between the transmitter and the plurality of spaced apart antennas can be demodulated within the at least one remote receiver.

44. The data communication system according to claim 42 wherein the means for providing a distinct delay is capable of providing a distinct delay associated with each antenna such that a time division multiple access (TDMA) communication signal coupled between the transmitter and the plurality of spaced apart antennas can be demodulated within the at least one remote receiver.

45. A data communication system comprising:
a transmitter having a plurality of spaced apart antennas;
at least one remote receiver in communication with the transmitter;
means for providing a derived version of each communication signal transmitted from a transmitter channel to the plurality of spaced apart antennas, wherein the means for providing a derived version of each communication signal is configured to amplitude scale a communication signal transmitted from the transmitter to the plurality of spaced apart antennas; and
means for providing a distinct delay associated with each antenna such that a derived version of a communication signal coupled between the transmitter and the plurality of spaced apart antennas can be demodulated within the at least one remote receiver.

46. The data communication system according to claim 45 wherein the means for providing a distinct delay is capable of providing a distinct delay associated with each antenna such that a code division multiple access (CDMA) communication signal coupled between the transmitter and the plurality of spaced apart antennas can be demodulated within the at least one remote receiver.

Variable	Mean	Standard deviation	Minimum	Maximum
Age	34.5	10.5	20	55
Gender	0.5	0.5	0	1
Marital status	0.5	0.5	0	1
Education	12.5	1.5	10	15
Income	1500	500	1000	2500
Health status	0.5	0.5	0	1
Smoking status	0.5	0.5	0	1
Alcohol consumption	0.5	0.5	0	1
Exercise frequency	0.5	0.5	0	1
Stress level	0.5	0.5	0	1
Life satisfaction	0.5	0.5	0	1
Overall health	0.5	0.5	0	1

Abstract of the Disclosure

A system and method of data communication uses variable transmit antenna delays based on communication signal uplink measurements. The signals for each channel are delayed at baseband, so different delays can be used for each channel. The delay between each antenna are preferably chosen so that the strongest paths do not overlap in order to implement full transmit antenna diversity. Where it is not possible to eliminate overlapping paths, the transmitted signals are recharacterized by phase shifts and/or amplitude scaling to derive signals that inherently possess the desired communication signal characteristics.

[illegible]

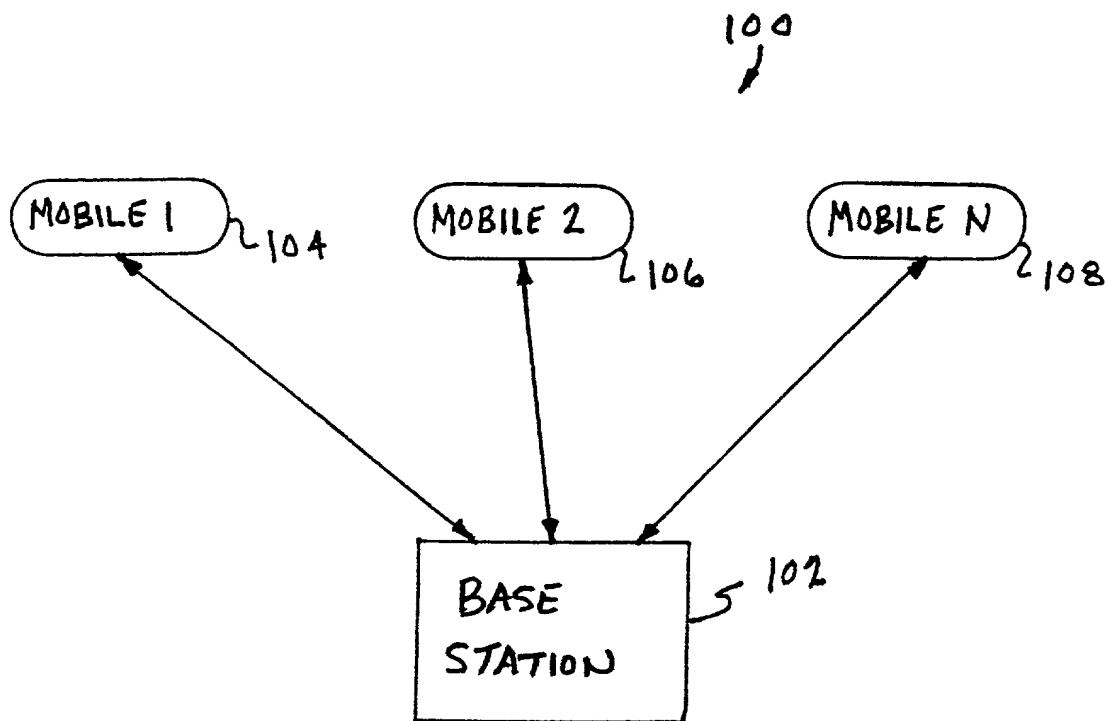
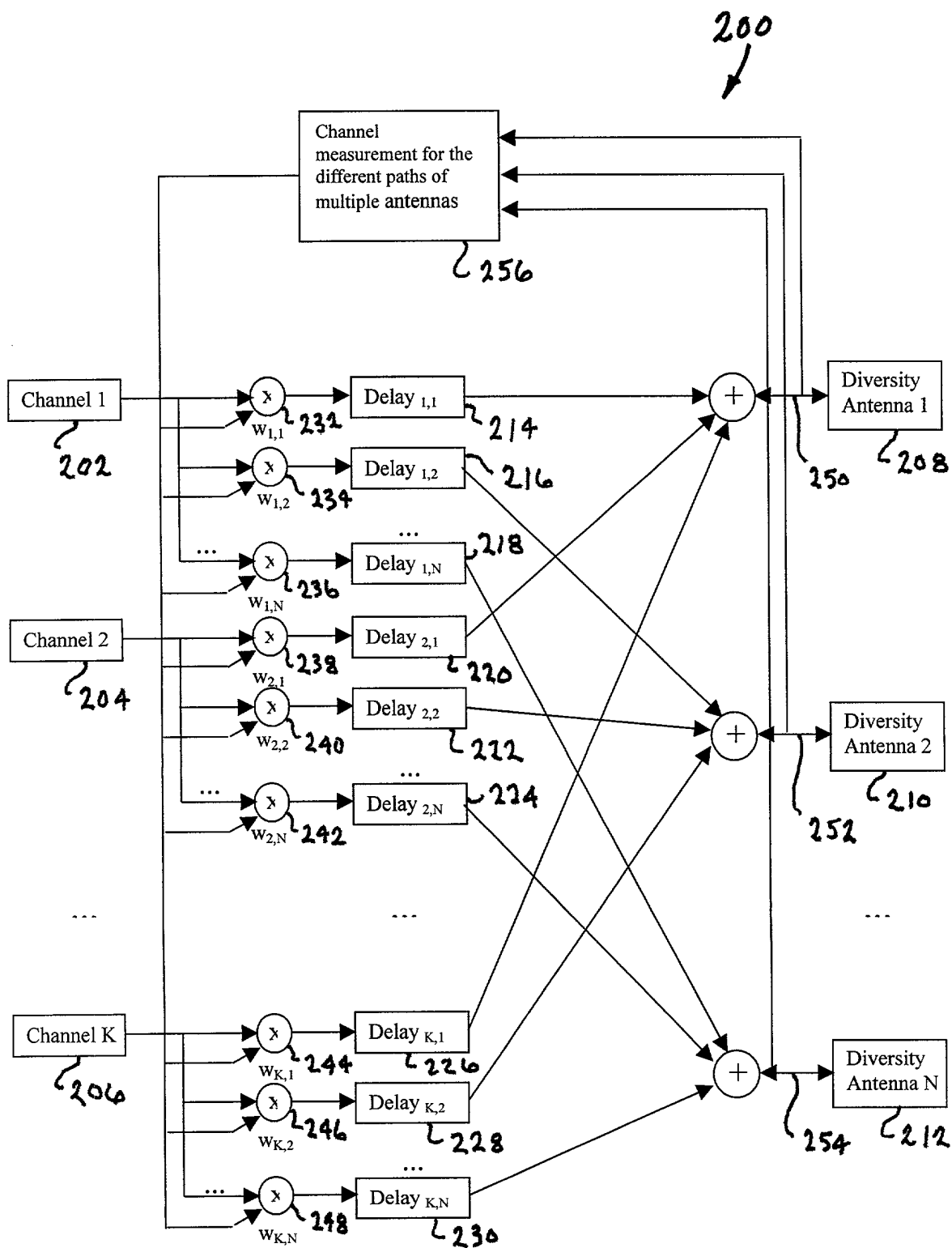


Figure 1

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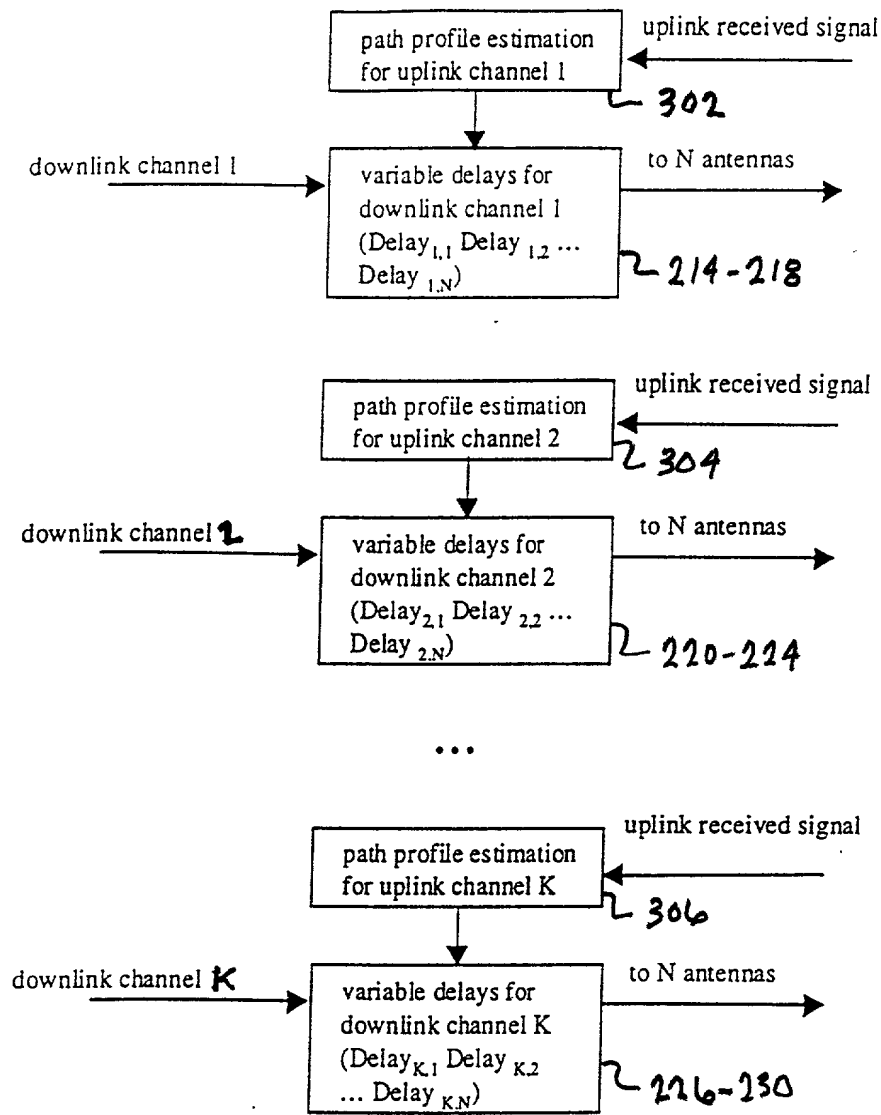


Figure 3: Method of choosing delays for each channel.



	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2
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Figure 5: Delay profile at the mobile with delay of 1 chip between the two transmit antennas.

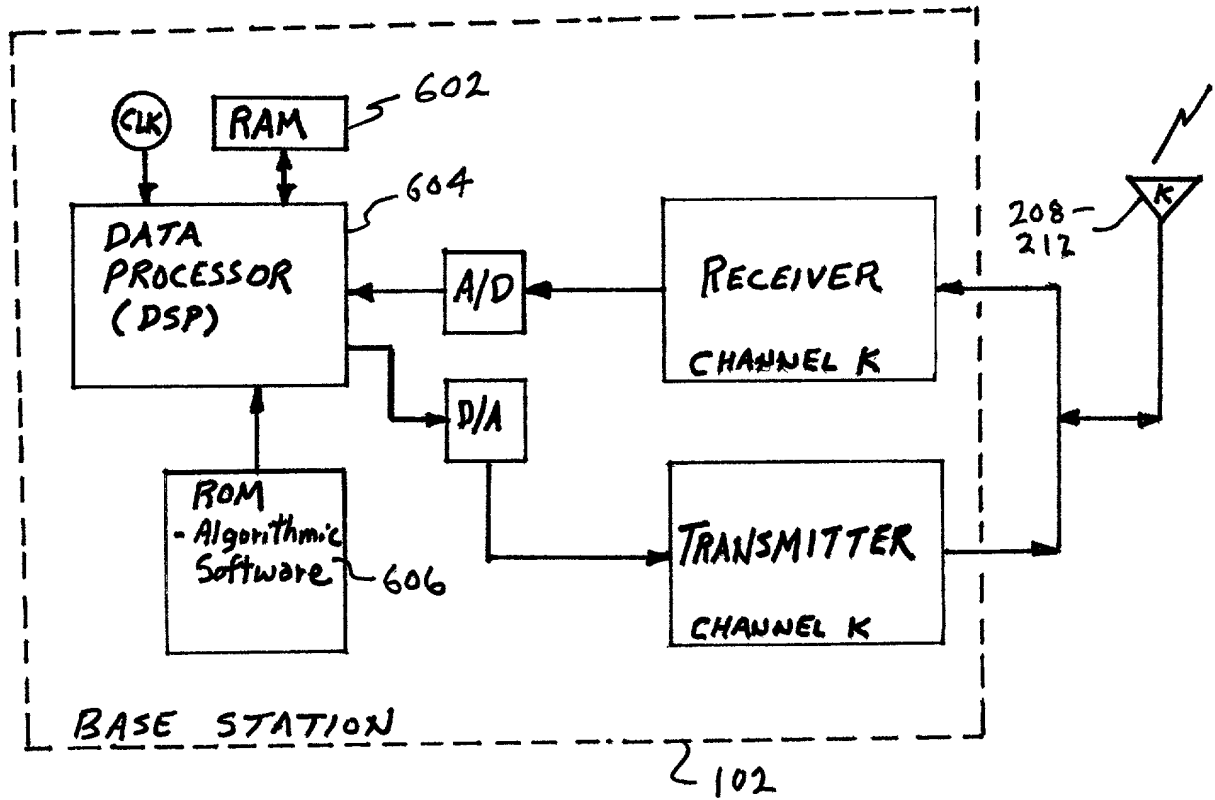


Figure 6

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700

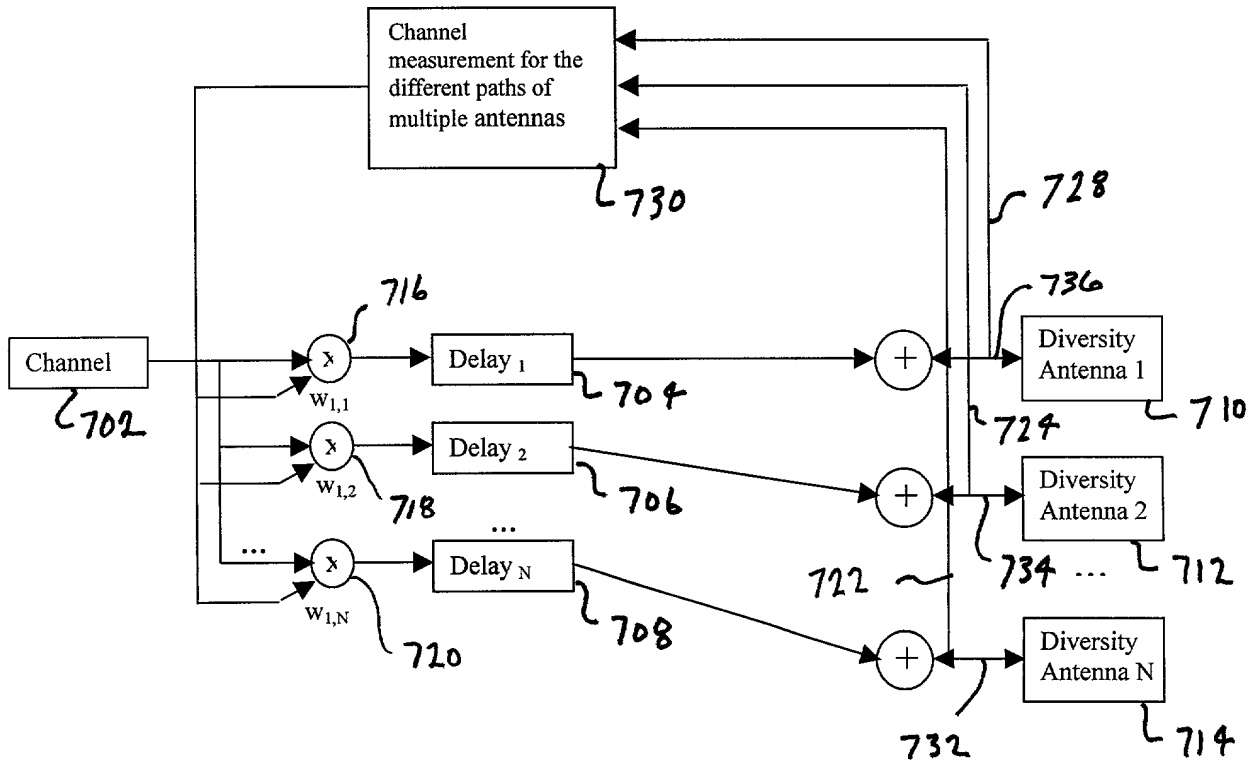
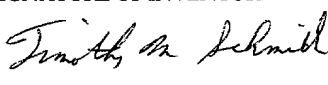
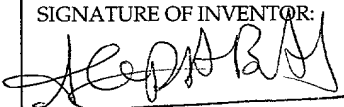


Figure 7

APPLICATION FOR UNITED STATES PATENT
DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I declare that my residence, post office address and citizenship are as stated below next to my name; that I verily believe that I am the original, first and sole inventor if only one name is listed below, or an original, first and joint inventor if plural inventors are named below, of the subject matter which is claimed and for which a patent is sought on the invention entitled as set forth below, which is described in the attached specification; that I have reviewed and understand the contents of the specification, including the claims, as amended by any amendment specifically referred to in the oath or declaration; that no application for patent or inventor's certificate on this invention has been filed by me or my legal representatives or assigns in any country foreign to the United States of America; and that I acknowledge my duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, section 1.56;

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

TITLE OF INVENTION: System and Method of Communication Using Combined Signal Parameter Diversity		
POWER OF ATTORNEY: I HEREBY APPOINT THE FOLLOWING ATTORNEYS TO PROSECUTE THIS APPLICATION AND TRANSACT ALL BUSINESS IN THE PATENT AND TRADEMARK OFFICE CONNECTED THEREWITH Robby T. Holland, Reg. No. 33,304; W. James Brady III, Reg. No. 32,080; Alan T. Stewart, Reg. No. 35,373; Mark E. Courtney, Reg. No. 36,491; Dennis J. Moore, Reg. No. 28,885; W. Daniel Swayze Jr., Reg. No. 34,478; Dwight N. Holmbo, Reg. No. 36,410; Jay M. Cantor, Reg. No. 19,906; April M. Mosby, Reg. No. 44,955; William B. Kempler, Reg. No. 28,228		
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COUNTRY OF CITIZENSHIP: U.S.A.	COUNTRY OF CITIZENSHIP: India	COUNTRY OF CITIZENSHIP:
SIGNATURE OF INVENTOR: 	SIGNATURE OF INVENTOR: 	SIGNATURE OF INVENTOR:
DATE: March 14, 2000	DATE: 03/14/2000	DATE: